IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES
ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 10, Iss 09, 2021

ANALYSIS AND PERFORMANCE OF STONE MATRIX ASPHALT WITH USING BAMBOO FIBERS

[1]Dr. P. LAKSHMAIAH CHOWDARY,[2]Y MANJUNATH,[3]M DHARMESH, [4]TELUGU AJAY KUMAR

[1]Associate Professor,[23]Assistant Professor,[4]Student

Department Of Civil Engineering

Bheema Institute of Technology and Science, Adoni

ABSTRACT

Better, more durable, and more effective roads that avoid or minimise bituminous pavement distresses are desperately needed given the rising traffic and maintenance costs. In flexible pavements, the Stone Matrix Asphalt (SMA) mixes provide a long-lasting wearing course. The purpose of this research is to identify the optimal surface course for pavements and examine how additives affect the properties of SMA mixes. Natural fibres including coir, sisal, and banana fibres were the additions employed in this study. An first inquiry is carried out to describe the items used in this research. Indirect tensile strength testing and the Marshall Test are used to investigate the engineering characteristics of stabilised mixes and optimise SMA mixtures, respectively. It is deduced that the ideal fibre concentration for all fibre mixes, regardless of the kind of fibre, is 0.3% fibre by weight of mixture based on the volumetric and mechanical properties of the different stabilised combinations. However, the volumetric measurements in every stabilised combination fall within the specified range. Of the fibres used in the experiment, coir is the best; combinations of sisal and banana fibres exhibit similar stabilising properties. In order to boost trust in the material's field use, the current research aims to provide a short overview of the engineering behaviour of the SMA mixture with different natural fibres added as additives
.

1. INTRODUCTION

Road network is vital to the economic development, social integration and trade of a country. Inadequate transportation facilities retards progress of socio-economic and cultural development of a country. Hence the main concept of present day transportation system is to provide safe, economic and efficient transportation facility for the travel of road users. From independence, transport demand in India was growing rapidly. As per the Road Network Assessment by NHAI, national parkways constitute roughly 2% of the aggregate street system of India, however convey about 40% of the aggregate activity with the length of 67,000 km of expressways interfacing all the real urban areas and state capitals. The vast majority of them are two-path parkways with cleared streets and are augmented to four paths and eight paths in created territories and substantial urban communities. As per latest reports, 19,064 km of the National Highway system still having singlelaned roads. The government is currently working on entire National Highway network consists of roads with two or more lanes. The total length of road in India had increased significantly from 3.99 lakh km as on 1951 to 42.36 lakh km as on 2008. Concomitantly, the surfaced road had increased from 1.57 lakh km to 20.90 lakh km over the same period. The increase in maintenance expenditure increases with the increase in vehicle registrations and this demands the urgent need for building better, long-lasting, and more efficient roads that

IJFANS International Journal of Food And Nutritional Sciences

prevents or minimizing bituminous pavement distresses. Roads in poor condition causes wear, tear to vehicles and even damage. Also, traffic queuing and delays occur when vehicles slow down to avoid important pavement distresses (e.g., potholes) or when the road surface fails to provide safe maneuvering and/or adequate stopping conditions. Due to the stagnation of water, many of the principal distresses in flexible pavement may occur. The mechanical properties of the material decreases and the serviceability of the pavement gets reduced due to moisture present in the pavement.

1.1. Research objectives

The main objectives focused in this research are discussed as below.

- The main objective of this study is to propose a durable wearing course with Stone Matrix Asphalt by exploring the application of additives such as natural fibres.
- To study the effect of additives in SMA and to achieve at the optimum additive content of the mixtures.
- To intend the best natural fibre additive from the fibre stabilized SMA mixtures.
- To suggest the best natural additive from all the SMA mixtures are investigated.

2. LITERATURE REVIEW

Literature review has to be carried out to identify the present conditions of roads in India, issues in maintenance and other problems related with durability. Thorough literature study has to be carried out to examine various researches on bituminous mixtures (Dense graded, Open graded and Gap graded mixtures) with and without addition of additives.

Based on the literature review, experimental research programme has to be formulated. As a preliminary investigation, acquirement of various ingredients of SMA and the evaluation of its properties are carried out. Marshall tests and indirect tensile strength test are proposed for the mix design (with and without additives) and for assessing the strength characteristics of SMA mixtures respectively. A comparative study on different characteristics (volumetric and mechanical) of various stabilized mixtures with the addition of varying additive contents and different types has carried out for optimization. The ideal mix has proposed from the various SMA mixtures with optimum additive content.

The history backdrop of the utilization of filaments can be followed back to a multi year old curve in China developed with a mud earth mixed with strands or the Great Wall fabricated 2000 years prior. Notwithstanding, the cutting edge improvements of fiber support began in the mid 1960 distributed the main known examination on support of bituminous blends. This examination assessed distinctive kinds of wire work put under an overlay trying to counteract reflection breaking. The investigation inferred that a wide range of wire support counteracts or significantly postponed the development of longitudinal breaks. Zube recommends that the usage of wire fortification enable the thickness of overlays to be diminished while accomplishing a similar execution. No issue was related to the steel and bituminous blend similarity [1].

Fibres are added as reinforced materials in bituminous mixtures. Some fibres have high rigidity in regard to bituminous blends, along these lines it was discovered that fibres can possibly improve the durable and elasticity of mixtures. Research and experience have demonstrated that fibres tend to perform superior to anything polymers in lessening the deplete down of bituminous solid mixtures, that is the reason fibres are generally suggested.

In perspective of the inborn likeness of filaments with bitumen and its amazing mechanical properties, the development of strands to bitumen improves material quality and exhaustion traits while meanwhile extending adaptability [2].

It is important to know that the suitable quantity of bitumen required to coat the fibres depends on the absorption rate and the surface area of fibres and also depends on the concentration and type of fibres. If the fibres are too long, it may create the so called ‘‘balling” problem, i.e., some of the fibres may lump together, and may not blend well with the bitumen. Similarly, too short fibres may not give any reinforcing effect. They serve as an expensive filler in the mix [3].

The test completed incorporates flexible modulus, roundabout elasticity, rutting opposition and weakness obstruction. Three examinations were carried on a test track in Nantes, France. The primary examination demonstrates that, fiber adjusted blends kept up the most elevated level of voids with a 13 metric ton pivot stack for 1.1 million times compared with unmodified and other twoelastomer altered blends. The creators presumed that diminished vulnerability to dampness related trouble in the permeable blends tried was because of better seepage. In the second examination, two million load applications were connected on fibre-changed bituminous blend was utilized as an overlay on the asphalts with indications of weakness trouble. After the heap applications, the black-top surface was noted to an all around cared for macrostructure, and in fact no part. Fiber changed overlays are also worked over depleted pavements in the third examination uncovered coordinated by them. After 1.2 million load applications, it was watched that all of fiber modified overlays exhibited no indication of shortcoming related pesters or rutting appeared differently in relation to the unmodified illustrations which clues at the distress.

This was in simultaneousness with the discoveries of the second investigation, setting up that the weakness life of the fiber adjusted asphalt is enhanced over unmodified bituminous blends. Fiber adjustment allows a development in film thickness, ensures in less ageing, improved clasp characteristics. Development of the fibers in bituminous mixes achieves the reduction of temperature helplessness of the bituminous blends [4,5].

The outline techniques for bituminous blends for the most part incorporate the notable Marshall plan strategy and Super clear plan method c seem to be the possibility to enhance weakness life and disfigurement attributes by increment the rutting obstruction. The tensile strength and its relative properties of mixtures containing fibres were found to improve. In terms of workability, mixtures having fibres showed a slight increase in the optimum binder content when compared to the other control mix. It is similar to the addition of very fine aggregates [6,7].

The natural coir fibre which is a less expensive and an ecofriendly alternative to synthetic fibre, can be efficiently used as a stabilizing additive in bituminous concrete. The rate of increase in retained stability of the mixture as compared to the conventional mix was around 14% at the optimum fibre content of 0.3% and the decrease in bitumen content is 5% giving an appreciable saving in binder.

3. Material characterisation

3.1. Material

The performance of bituminous surfacing depends on the correct choice of quality and quantity of materials that are used. Materials need for the production of Stone Matrix Asphalt mixtures includes high quality aggregates, bituminous binder, mineral filler and a stabilizer. The materials used in this research work are locally available construction materials in Nellore. The properties of the different materials used for the research are described in this chapter.

3.1.1. Aggregates

Aggregates frame the significant constituent of street development materials. Since they need to hold up under the brunt of movement, they ought to be sufficiently solid to oppose the debasement and ought to have enough auxiliary steadiness which is offered by the mechanical interlock of total in the layer. IS 2386-1963 gives the strategies for tests for totals in street development. Total of sizes 20 mm, 10 mm and stone residue procure from a neighborhood quarry is utilized as a part of the present examination. The qualities got for various properties of aggregates are given in Table 1.

Table 1
Physical properties of the aggregate.

Property	Values obtained	Method of Test
Aggregate impact value (%)	14	IS:2386 (IV)
Los Angeles Abrasion Value	23	IS:2386 (IV)
Combined Flakiness and Elongation Index (%)	18	IS:2386 (I)
Water Absorption (%)	1.1	IS:2386 (III)
Specific gravity	2.65	IS:2386 (III)

3.1.2. Mineral filler

The part of mineral filler is basically to harden the rich cover SMA. It is intended to satisfy the voids and structures a firm mastic with bitumen fastener and settling added substance. It builds the attachment of the blend which comes about a noteworthy increment in the shear obstruction. The high level of filler may solidifies the blend unnecessarily and making it hard to minimized and might bring about a split defenseless blend. When all is said in done, the measure of material going through 0.075 mm sifter is 8–12% of the aggregate sum of total in the blend. The regularly utilized mineral fillers are fly fiery debris, hydrated lime, finely ground limestone residue and customary Portland bond (OPC). OPC accessible from a nearby market which improves a security with total, bitumen and added substance was utilized as a part of the present work. The physica1 properties of filler material utilized are shown in Table 2.

Table 2
Physical properties of the cement.

Physical property	Values obtained
Specific gravity	3.11
% passing 0.075 mm sieve (ASTM C117)	95

3.2. Stabilizing additives

Stabilizing additive must be used to hold the binder in SMA mix during mixing, transporting and placement operations. To prevent the unacceptable drain down, fibres or polymers as stabilizing additives can be added to the mixture. The three natural fibres namely coir, sisal and banana fibre are used as stabilizing additives in the present study. The description of these three materials is given below.

3.2.1. Fibre stabilizer

There are different sorts of strands utilized as a part of SMA blends like polymer fiber, mineral fiber, regular filaments and so forth. In this examination, three normal fibres are utilized to be specific, coir, sisal and banana fiber at various rates by weight of blend. The photos of the three fibres are appeared in Fig. 1.

3.2.2. Coir fibre

Kerala is the home land of Indian coir industry, accounting for 61 per cent of coconut production and over 85 per cent of coir products. Coconut fibre/ coir fibre derived from the mesocarp tissue or husk of the coconut fruit. The individual cells of coconut fiber are restricted and empty, with1thick dividers made up of cellulose. The lengths of such filaments are regularly in the scope of 15–280 mm and breadth differs from 0.1 mm to 1.5 mm. The normal elasticity of fiber was observed to be 70.58 N/mm2. Contrasted and different vegetable fibres, the coconut fiber has a cellulose substance of 36% to 43%, and lignin substance of 41% to 45%. The coir strands for the present work had gotten from Alappuzha and its properties are given in Table 3.

3.2.3. Sisal fibre

Sisal plantations in India yield about 2.5 tonnes dry fibre per hectare in a year. The fibre is generally acquired from sisal leaves by decortications in a machine called Raspador. Sisal is a leaf fiber got from the plant Agave Sisalana. Its properties are given in Table 3.

3.2.4. Banana fibre

The entire sheath of banana fibre yields good quality fibre which is highly valued in the market for its durability and strength. A large quantity of bio waste is generated every year owing to banana cultivation which needs to be disposed off. By extracting banana fibre, the waste can be effectively utilized and provide additional income to the banana farmers. The banana fiber required for doing the work had secured from Kerala Agricultural University, Banana Research station, Kannara, Thrissur, Kerala and the properties of the fibre are given in Table 3.

Table 3
Properties of fibres used.

Property	Coir fibre	Sisal fibre	Banana fibre
Diameter (μm)	100–450	50–200	80–250
Density (g/cm^3)	1.45	1.40	1.35
Cellulose content (%)	43	67	65
Lignin content (%)	45	12	5
Elastic modulus (GN/m^2)	4–6	9–16	8–20
Tenacity (MN/m^2)	131–175	568–640	529–754
Elongation at break (%)	15–40	3–7	1.0–1.2

3.2.5. Bitumen

Bitumen goes about as a fastener in the SMA blend. Bitumen of VG-30 review acquired from Vishakhapatnam Refineries was utilized as a part of the planning of blend tests. The Physical properties of bitumen are found and the results are given in Table 4.

Table 4
Physical properties of bitumen.

Property	Result obtained	Test procedure as per specification
Specific Gravity @ 27 °C	1.03	IS:1202-1978
Softening Point (°C)	52	IS:1205-1978
Penetration @ 25 °C, 0.1 mm 100 g, 5 s	64	IS:1203-1978
Ductility @ 27 °C (cm)	72	IS:1208-1978
Flash Point (°C)	240	IS:1209-1978
Fire Point (°C)	270	
Viscosity at 60 °C (Poise)	1200	IS:1206-1978

4. Results and discussion

The indirect tensile strength results of SMA mixtures with various added substances at different rates both for adapted and unconditioned examples are given in Table 5. It is clear that all the balanced out SMA blends demonstrated higher elasticity than the control blends regardless of sort of the added substance. This is a direct result of enhanced solidness of balanced out blend than that of control blend. It is additionally watched that for all SMA blends, the rigidity diminishes with molding paying little mind to the sort of added substance. Yet, the rate diminish in quality because of the molding of the example diminishes with the expansion in added substance content. For the control blend, the rate diminish in quality because of molding is around 48%, while at higher added substance, for every one of the added substances, the rate diminish is less (<3%).

Table 5
Indirect tensile strength results for stabilized SMA mixtures.

Additive	%	ITS, Unconditioned (MPa)	ITS, Conditioned (MPa)	% TSR (MPa)
Nil	0	0.8143	0.4253	52.23
Coirfibre	0.1	0.851	0.709	83.31
	0.2	1.0983	1.059	96.42
	0.3	1.1242	1.1048	98.27
	0.4	1.0831	1.0521	97.14
Sisal fibre	0.1	0.8313	0.6915	83.18
	0.2	1.0619	1.0114	95.24
	0.3	1.1057	1.0766	97.37
	0.4	1.0538	1.0153	96.35
Banana fibre	0.1	0.8272	0.6941	83.91
	0.2	1.065	1.0107	94.90
	0.3	1.1018	1.0762	97.68
	0.4	1.054	1.015	96.30

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 10, Iss 09, 2021

Fig. 1. Fibres used for the present study

4.1. Fibre stabilized SMA

The varieties of roundabout rigidity of Stone Matrix Asphalt blends with various rates of fiber substance are given in Figs. 2–4. The elasticity of SMA blends with fiber added substance indicates expanding pattern up to 0.3% and it is observed to diminish at 0.4% fiber content. This conduct is on the grounds that, the elasticity is connected basically to a component of the cover properties, and its solidness impacts the rigidity. Nearness of fiber in the blend makes it stiffer. The expansion of fiber past a specific level can build the consistency of folio, which comes about because of the impacts of increment in volume of fiber particles because of the retention of cover. Thusly, this expansion in thickness restrains the capacity of the fastener to coat enough on the surface of totals, subsequently prompt the potential loss of bonds between the fiber, binder and the aggregate.

A comparison of elasticity attributes for the three fiber balanced out SMA blends both for unconditioned and adapted are given in Figs. 5 and 6. All the fiber settled SMA blends have the greatest rigidity at 0.3% fiber content by weight of blend for both adapted and unconditioned SMA blends. The rate increment in quality for the coir fiber balanced out blend (0.3% fiber content) regarding the control blend is 38% and 160% individually for unconditioned and adapted examples. This expansion is around 36% and 153% individually for both sisal and banana fiber settled blends. The change in backhanded elasticity would be expected to fibre's assimilation and attachment of bitumen which enhances the interface grip quality and fiber's organizing and crossing over splitting impacts. Fiber fortifying impact increments at first with expanding fiber content; however at high fiber content (over 0.3%) may prompt coagulation and subsequently decreasing its strengthening impact. The higher amount of fibre in the mixture may not have any beneficial effect and may deteriorate its deformation properties. In fibre stabilized mixtures, large amount of fibre leads to higher surface area that must be coated by bitumen, and consequently, the aggregate particles and fibre would not be fully coated with bitumen. Test results show that coir fibre stabilized mixtures has the highest tensile strength as compared to the other two mixtures.

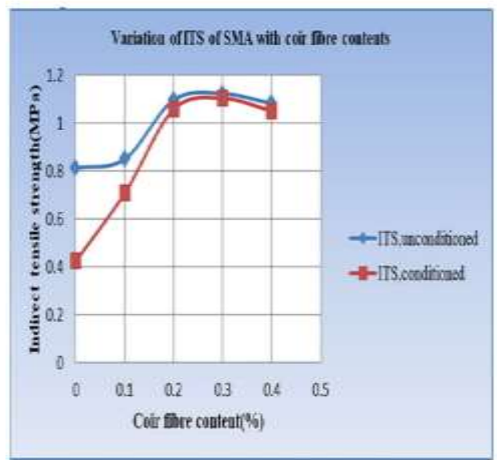

Fig. 2. Variation of indirect tensile strength of SMA with coir fibre contents.

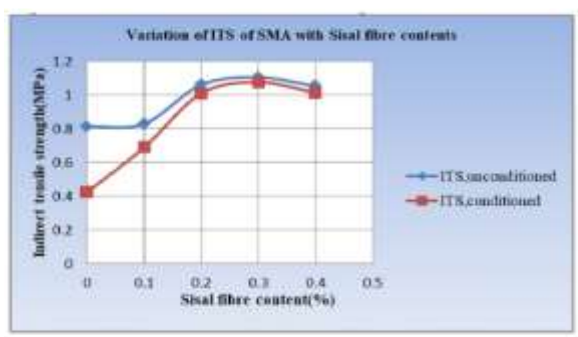

Fig. 3. Variation of indirect tensile strength of SMA with sisal fibre contents.

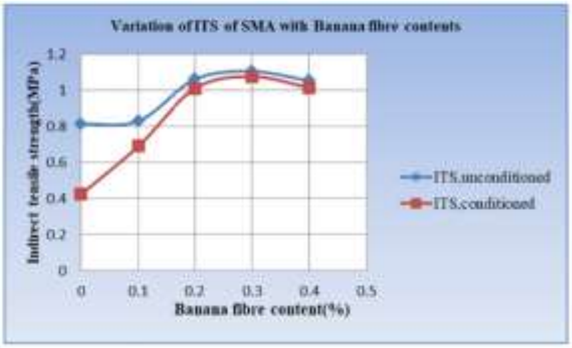

Fig. 4. Variation of indirect tensile strength of SMA with banana fibre contents.

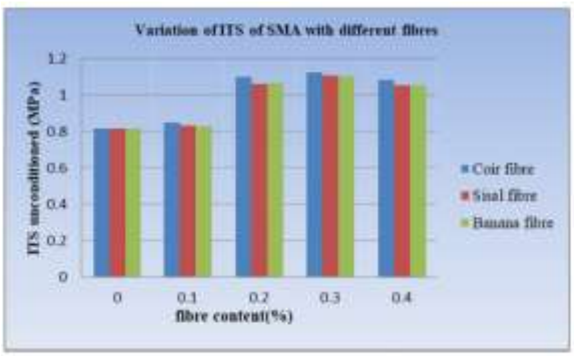

Fig. 5. Variation of indirect tensile strength of SMA (unconditioned) with different fibre contents.

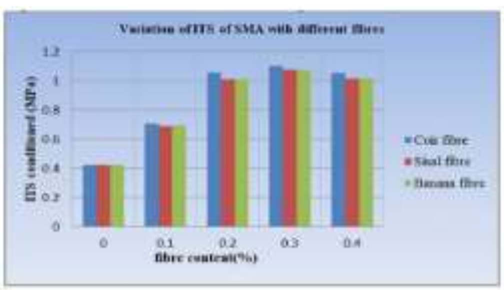

Fig. 6. Variation of indirect tensile strength of SMA (conditioned) with different fibre contents.

4.2. Comparison of different SMA mixtures

It is obvious that the rate increment in quality is high if there should arise an occurrence of very molded example of balanced out SMA regarding the control blend. The most extreme rate increment is for SMA with coir fiber and the base for that with banana fiber (160% and 153% individually). The rigidity esteem for examples with coir fiber is higher when contrasted with that with sisal and banana strands (demonstrates around comparable quality). The blends had the most noteworthy firmness and the rate increment in quality is around 11% at both unconditioned and adapted SMA blend when contrasted with coir fiber balanced out blend.

4.3. Moisture susceptibility of SMA mixtures

As given in Table 5. the tensile strength ratio (TSR) estimations of the control blend is about 52% which is under 70%, a base TSR esteem put forward by AASHTO T283. This outline the control blend has more huge dampness powerlessness. The elasticity proportions for the blends containing the added substances are more prominent than as far as possible. From these outcomes, it can be inferred that the nearness of added substances fundamentally lessens the dampness incited harm of the SMA mix. This additionally shows the added substances don't make the blend debilitate when presented to dampness. The outcomes likewise shows the rigidity proportion to the dampness defenselessness expanded up to a specific level of added substances and from that point onward, it is observed to diminish. In fiber balanced out mix, the diminishing in TSR at higher fibre content might be due to the balling effect of the fibres in the mix.

From Fig. 7, it is evident that among the fibre stabilized mixtures SMA with coir fibre gives a slightly higher tensile strength ratio than the SMA with other fibres. The specimens containing sisal and banana fibre produced almost similar results. It is increasing with respect to the control mixture when additives are added and the increase is somewhat similar. It can be concluded that all stabilized mixes satisfy the minimum required tensile strength ratios of 70% indicating their better moisture resistance than the control mixture.

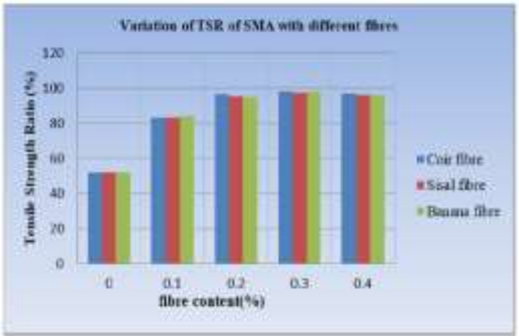

Fig. 7. Variation of tensile strength ratios of SMA with different fibre contents

5. CONCLUSIONS

With 0.3% fibre content, all of the fiber-balanced SMA mixes have the highest level of stiffness. Compared to the other fibre settled blends, the coir fibre balanced out SMA has the highest elasticity, indicating its stronger splitting opposition. For the coir fibre balanced out blend, the rate increase in quality is 38% for unconditioned instances and 160% for adapted examples; for the sisal and banana fibre settled blends, it is around 35% and 153%, respectively.

• The reinforcing impact of fibre in SMA rises initially as the quantity of fibre increases; however, at high fibre content (more than 0.3%), coagulation is induced, which reduces the reinforcing action of fibre and produces a less stiff mixture with lower strength values.

The test findings all point to the same conclusion: coir fibre and a 0.3% fibre content provide the optimum performance for the Stone Matrix Asphalt combination.

5.1. Moisture susceptibility

- SMA mixes with fibres have greater maintained stability, tensile strength ratios, and retained strength indexes at 0.3% fibre content by weight of mix. SMA with coir fibre exhibits the highest performance, showing a stronger resistance to damages caused by moisture.
- The optimal fibre content of the fiber-stabilized Stone Matrix Asphalt combination is 0.3% by weight of mixture, and the best fibre among the fibres studied is coir fibre additive, according to the volumetric and mechanical properties of the different fiber-stabilized mixes.

REFERENCES

[1] AASHTO T 245, Standard Method of Test for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus, American Association of State Highway and Transportation Officials, Washington DC, 1997.

[2] AASHTO T 283, Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage, American Association of State Highway and Transportation Officials, Washington DC, 2007.

[3] D.A. Anderson, L. Lapalu, M.O. Marateanu, Y.M.L. Hir, J.P. Planche, D. Martin, Low-temperature thermal cracking of asphalt binders as ranked by strength and fracture properties, J. Trans. Res. Board 1766 (2001) 1–6.

[4] ASTM D2041, Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Materials, American Society for Testing and Materials, Philadelphia, 1995.

[5] S.D. Attri, T. Ajit, Climate profile of India, Government of India Ministry of Earth Sciences, Meteorological Department Environment, 2010.

[6] Austroads, Selection and Design of Asphalt Mixes, Australian Provisional Guide, APRG Report No. 18 (1993).

[7] T.S.R. Ayyar, C.G.R. Nair, N.B. Nair, Comprehensive Reference Book on Coir Geotextiles, Centre for Development of Coir Technology, Thiruvananthapuram, 2002.